205a American Soda/Yankee Gulch
Class I Permit Application
3/11/1997
C010790-04358

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

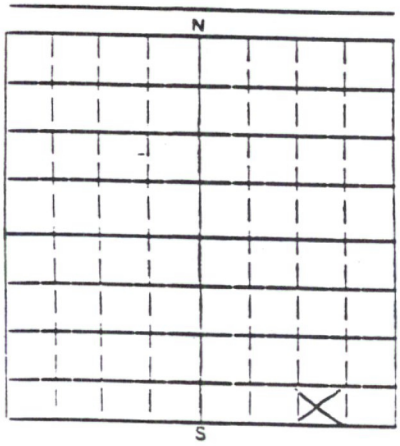
EPA COMPLETION REPORT FOR BRINE DISPOSAL, HYDROCARBON STORAGE, OR ENHANCED RECOVERY WELL

Form Approved
OMB No. 2040-0042
Approval expires 9-30-86

NAME AND ADDRESS OF EXISTING PERMITTEE
AMERICAN SODA, L.L.P.
PO BOX 2070
GLENWOOD SPRINGS, CO 81601

NAME AND ADDRESS OF SURFACE OWNER
BUREAU OF LAND MANAGEMENT
73544 HIGHWAY 64
MEEKER, CO 81641

LOCATE WELL AND OUTLINE UNIT ON SECTION PLAT — 640 ACRES



STATE	COUNTY	PERMIT NUMBER
CO	RIO BLANCO	CO1790-04358

SURFACE LOCATION DESCRIPTION
SW ¼ OF SE ¼ OF SE ¼ SECTION 20 TOWNSHIP 1S RANGE 97W

LOCATE WELL IN TWO DIRECTIONS FROM NEAREST LINES OF QUARTER SECTION AND DRILLING UNIT
Surface Location 466 ft. from (N/S) S Line of quarter section
and 1010 ft. from (E/W) E Line of quarter section

WELL ACTIVITY
- [X] Brine Disposal
- [ ] Enhanced Recovery
- [ ] Hydrocarbon Storage

TYPE OF PERMIT
- [X] Individual
- [ ] Area

Number of Wells 1

Estimated Fracture Pressure of Injection Zone
NA - HIGHLY FRACTURED ZONE

Anticipated Daily Injection Volume (Bbls)		Injection Interval	
Average	Maximum	Feet	to Feet
NA	NA	1280	1,400

Anticipated Daily Injection Pressure (PSI)		Depth to Bottom of Lowermost Freshwater Formation (Feet)
Average	Maximum	
400 PSIG	600 PSIG	ESTIMATED 1,150

Type of Injection Fluid *(Check the appropriate block(s))*
- [ ] Salt Water
- [ ] Brackish Water
- [ ] Fresh Water
- [ ] Liquid Hydrocarbon
- [X] Other: SODIUM SOLUTIONS

Lease Name YANKEE GULCH JOINT VENTURE **Well Number** 20-6

Name of Injection Zone LOWER AQUIFER

Date Drilling Began 1/13/99 **Date Well Completed** 1/21/99

Date Drilling Completed 1/16/99

Permeability of Injection Zone

Porosity of Injection Zone

CASING AND TUBING / CEMENT / HOLE

OD Size (IN)	Wt/Ft — Grade — New or Used	Depth (FT)	Sacks	Class	Depth (FT)	Bit Diameter (IN)
14	NEW	0-40	47	CLASS II	0-40	19
7	23 LB/FT J55 NEW	0-1,200	1,131	CLASS II	0-1,178	12.25
4.5	10.5 LB/FT NEW	0-1,280		BENTONITE GROUT	1,178-1,194	12.25
4.5	" SLOTTED NEW	1280-1,400				

INJECTION ZONE STIMULATION

Interval Treated	Materials and Amount Used

WIRE LINE LOGS, LIST EACH TYPE

Log Types	Logged Intervals
NATURAL GAMMA	0-1,471.5
RESISTIVITY 16/64	
SPONTANEOUS POTENTIAL	
TEMPERATURE, ΔTEMP.	
3-LEG CALIPER	
DEVIATION	
CEMENT BOND	

Complete Attachments A — E listed on the reverse.

CERTIFICATION

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. (Ref. 40 CFR 144.32).

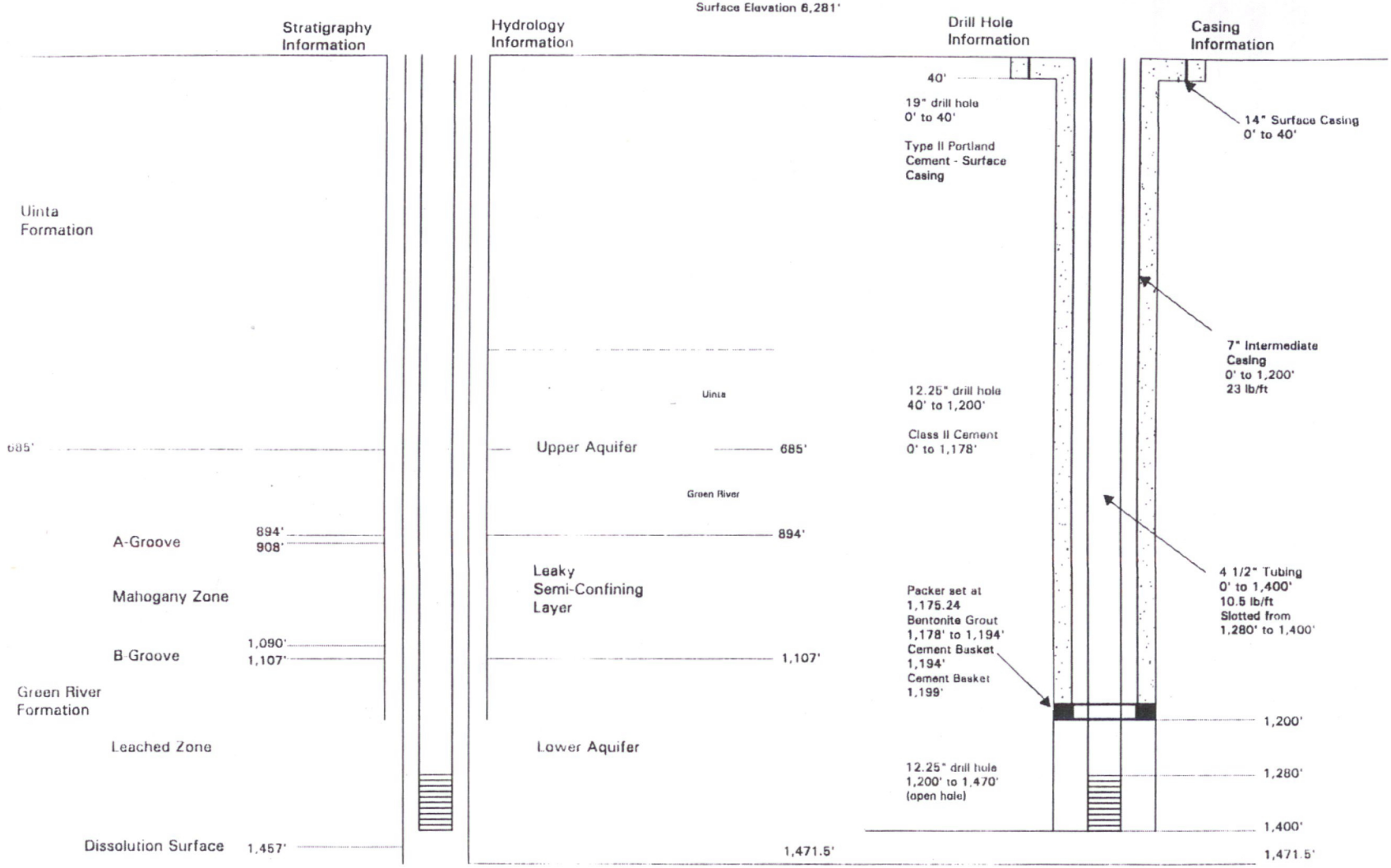
NAME AND OFFICIAL TITLE *(Please type or print)*
KURT NIELSEN, GENERAL MGR

Kurt Nielsen

DATE SIGNED
1/29/99

WELL 20-6

Surface Elevation 6,281'



Yankee Gulch Sodium Minerals Project

AMERICAN SODA, L.L.P.

WELL 20-6
COMPLETION DIAGRAM

Prepared by

STEIGERS CORPORATION

Well 20-6
Yankee Gulch Sodium Minerals Project
American Soda, L.L.P.

performed a pump test of the Lower Aquifer on the U.S. Bureau of Mines (USBM) Horse Draw Mine Research Facility site, and, although the test was very short, they estimate a transmissivity of 210 ft^2/d (Dale and Weeks 1978).

The base of the Lower Aquifer occurs at the Dissolution Surface, which is coincident with the top of the Saline Zone. The Saline Zone is composed of impermeable saline deposits with characteristic low fracture density.

Groundwater reserves in the Piceance Basin are large in both areal extent and volume. The total estimated groundwater reserves are estimated at 25 million acre-feet (BLM 1983), with over 2.5 million acre-feet in the Lower Aquifer (Coffin et al. 1971). Disposal of the solution mining leachates will involve injection of partially saturated to saturated sodium bicarbonate solution into the lower part of the highly fractured and rubblized Lower Aquifer where it will mix with the existing saline groundwater. The quantities of solution to be disposed of through injection into the Lower Aquifer are insignificant compared to the total 2.5 million acre-feet of groundwater reserves of the Lower Aquifer. The anticipated average injection rates of 39 to 162 gpm would equate to approximately 63 to 261 acre-feet per year added to the aquifer system. These volumes represent 0.0025 to 0.01 percent of the total volume of the Lower Aquifer and are an order of magnitude less when compared to the entire aquifer system. Therefore, no change in pressure or native fluid displacement can be reasonably expected to occur as a result of the introduction of this negligible volume of fluid into the Lower Aquifer.

D.1.3 Groundwater Quality

Baseline groundwater quality data on the aquifers in the Piceance Creek Basin have been collected by the USGS, Multi-Mineral Corporation, Gulf Oil, Standard Oil Company (Indiana), and others. The following discussion presents data describing the existing groundwater quality, both on a regional and a site-specific basis.

D.1.3.1 Regional Groundwater Quality

The chemical quality of groundwater in the Piceance Creek Basin varies both within and among the aquifers. Weeks and others indicate that the groundwater in the Alluvial Aquifer and the Upper and Lower Aquifers does not generally meet the standards recommended by the U.S. Public Health Service although it is commonly used for livestock watering and supplies some local ranches (Weeks et al. 1974).

The water in the alluvium is classified as a sodium bicarbonate type. Concentrations of major ions indicate that the alluvial groundwater is similar in chemistry to that of the Upper Aquifer. Concentrations of total dissolved solids (TDS) range from 470 to 6,720 mg/l and average 1,750 mg/l over the entire basin (Weeks et al. 1974). Generally, concentrations of dissolved solids increase in the downstream direction, with increases in sodium and bicarbonate from recharge areas to discharge areas. These increases are believed to reflect influences from irrigation-return flows, contributions from bedrock groundwater discharging to the alluvium, and concentration by evapotranspiration.

In general, water in the Upper Aquifer is of better quality than that in the Lower Aquifer. Water in the Upper Aquifer can be classified as a sodium bicarbonate type with a TDS concentration ranging from less than 400 to 2,000 mg/l (Weeks et al. 1974). Calcium, magnesium, and sulfate concentrations in the Upper Aquifer are greater than in the Lower Aquifer.

The Lower Aquifer can be classified as a sodium bicarbonate-chloride type with TDS concentrations ranging from less than 650 to greater than 60,000 mg/l and averaging over 13,000 ppm. Most of the highest TDS concentrations are located just above the top of the Saline Zone near the Dissolution Surface (Coffin et al. 1971). Throughout the basin, the Lower Aquifer characteristically exhibits a much higher concentration of fluoride than the Upper Aquifer. Wells sampled in the Lower Aquifer on the C-a and C-b oil shale tracts for the period 1974 through 1976 had average fluoride values of 14.7 and 21.0 mg/l, respectively.

Weeks and others report that concentrations of some trace elements in the Lower Aquifer are great enough to be of environmental concern (Weeks et al. 1974). Barium, boron, and lithium are consistently found in high concentrations in the northern part of the basin, and concentrations of barium occasionally exceed drinking water standards. Other constituents in the groundwater that have elevated values and, on average, exceed drinking water standards include arsenic, cadmium, chloride, iron, mercury, manganese, lead, and selenium. Elevated levels of barium, boron, lithium, copper, chromium, strontium, and fluoride are also common in this geohydrologic unit.

D.1.3.2 Site-Specific Groundwater Quality

A number of groundwater samples have been collected from the Upper and Lower Aquifer systems directly to the west and southwest of the American Soda Test Area, including those from testing conducted by the Multi-Mineral Corporation, the USBM, and the USGS.

Site-specific water quality data have been collected from the American Soda property. The results of groundwater sampling of the Upper Aquifer from American Soda's recently completed water supply well are provided in Table D-1. Results of groundwater sampling of the Upper and Lower Aquifers from American Soda's solution mining well are provided in Table D-2.

Upper Aquifer

Water quality data for the Upper Aquifer in the vicinity of the American Soda property are presented in Ficke et al. (1974), Weeks and Welder (1974), Weeks et al. (1974), Welder and Saulnier (1978), and Daub et al. (1985). Upper Aquifer waters are a sodium bicarbonate type. Total dissolved solids have been reported at approximately 900 to 1,000 mg/l, and the highest sulfate reading near the American Soda property was 470 mg/l from well USGS-75-6A.

Water samples from the recently completed American Soda water supply and solution mining wells exhibit TDS concentrations in the Uinta Formation portion of the Upper Aquifer ranging from 944 to 1,260 mg/l at depths of 357 to 560 feet (Agapito 1997b, Agapito 1997c, Agapito 1997d). TDS concentrations increase in the Green River Formation (Parachute Creek Member) portion of the Upper Aquifer, with the water sample from 811 feet, immediately above the Mahogany Zone, yielding a TDS concentration of 15,900 mg/l (Agapito 1997d).[2]

Lower Aquifer

As in the Upper Aquifer, the groundwater may be classed as a sodium bicarbonate type, but with a higher overall TDS concentration. A water quality sample from a nearby USGS well, USGS-75-6B, showed similar characteristics to the Upper Aquifer, but with much higher concentrations. TDS concentration of this sample was 9,610 mg/l, with sulfate, sodium, and fluoride concentrations of 63, 3,900, and 26 mg/l, respectively. Since this well was open to the entire Lower Aquifer system, the water sample is a composite representing the average quality of all individual water-bearing zones. Welder and Saulnier collected water of similar quality from test holes drilled in the Piceance Creek Basin, and Weeks and others reported water quality data with similar characteristics (Welder and Saulnier 1978, Weeks et al. 1974). The water sample from the lower part of the Lower Aquifer at the American Soda solution mining well exhibits a TDS concentration at 1,411 feet, immediately above the Dissolution Surface, of 26,600 mg/l (see footnote 2) (Agapito 1997d). Conductivity measurements suggest that Lower Aquifer TDS concentrations likely range from approximately 19,000 to as high as 33,000 mg/l immediately above the Dissolution Surface in the American Soda Test Area (Agapito 1997a, Agapito 1997b, Agapito 1997d).

The screened interval of the injection well will be placed between 140 feet and 40 feet above the Dissolution Surface in the lower portion of the Lower Aquifer. The salinity of the Lower Aquifer increases and water quality deteriorates with depth towards the Dissolution Surface (Welder and Saulnier 1978, Daub personal communication 1996). The TDS concentration of the Lower Aquifer is estimated to range to over 60,000 mg/l. The Colorado Department of Public Health and Environment considers water with total dissolved solids in excess of 10,000 ppm (10,000 mg/l) to be nonpotable. The Lower Aquifer does not meet the standard for drinking water because of marginal pH and high concentrations of fluoride, arsenic, cadmium, chloride, iron, mercury, manganese, lead, and selenium. Elevated levels of barium, boron, lithium, copper, chromium, and

---

[2] It should be noted that all American Soda TDS estimates presented here are considered to be conservative for the following reasons: 1) analytical TDS concentrations are lower than expected based on the generally high degree of correlation of TDS and conductivity in the absence of high levels of organic compounds and 2) analytical TDS concentrations are lower than the sum of all anions and cations analyzed. It is felt that these low TDS values are an artifact of the analytical method (heating and evaporation), which would cause dissociation of the sodium bicarbonate to sodium carbonate, carbon dioxide, and water, with loss of the produced carbon dioxide and water to the atmosphere. Compared to conductivity measurements, analytical TDS concentrations are 15 to 40 percent lower than expected.

strontium are also common. The Lower Aquifer does not meet the standards for irrigation water because of marginal pH and excessive molybdenum and fluoride. The introduction of saline water into water that is already highly saline is considered to have no adverse effect.

Based on the relatively insignificant quantities of injection fluids compared with the groundwater reserves (see Section D.1.2.2, above) and on the poor existing quality of the groundwater, it is unlikely that disposal of the solutions from the experimental test cavity will have any adverse impact on the groundwater quality of the Piceance Creek Basin aquifers.

D.2 CURRENT USES OF GROUNDWATER IN THE AREA

Very little groundwater development has occurred in the Piceance Creek Basin. Historically, the principal, long-term use of groundwater has been livestock watering. However, past activities associated with the development of oil shale in the region promoted the withdrawal of groundwater. Generally, oil shale development required dewatering of the Mahogany Zone to allow for mining activities or for modified in-situ extraction of shale oil. The water produced from these activities was either reinjected, discharged to surface streams, or used for irrigation. According to the Colorado State Water Engineers office and the Colorado Department of Public Health and Environment, no public water supply wells are located in Townships 1 or 2 South, Ranges 97 or 98 West, Sixth Prime Meridian.

Table D-1 Groundwater Quality of the Upper Aquifer from American Soda's Water Supply Well (Hole 20-8).

Parameter	Upper Aquifer		
	430 feet	560 feet	560 feet (Pump Test)
Total Alkalinity as $CaCO_3$ (mg/l)	477	637	655
Phenol Alkalinity as $CaCO_3$ (mg/l)	26.6	42.0	0
Bicarbonate (mg/l)	517	675	793
Carbonate (mg/l)	31.9	50.4	0
Boron (mg/l)	0.137	0.158	0.163
Bromide (mg/l)	0.03	0.05	0.07
Calcium (mg/l)	39.1	17	23
Total Organic Carbon (mg/l)	38.0	5.20	48.0
Chloride (mg/l)	16	25	20
Conductivity, 25°C (µmhos/cm)	1,180	1,480	1,790
Fluoride (mg/l)	0.54	4.0	3.72
Hardness as $CaCO_3$ (mg/l)	311	265	245
Hydroxide (mg/l)	0	0	0
Magnesium (mg/l)	53	45	48
Nitrate (mg/l)	0.77	0.19	0.24
Nitrite (mg/l)	<0.01	<0.01	<0.01
pH (units)	8.3	8.3	7.8
Phosphate (mg/l)	0.18	0.04	<0.01
Total Phosphorous (mg/l)	0.20	0.05	0.04
Potassium (mg/l)	8.1	1.7	2.3
Silica (mg/l)	28.4	19.8	15.9
Sodium (mg/l)	170	276	296
Sulfate (mg/l)	187	178	148
Sulfide (mg/l)	0.16	0.80	1.80
Total Dissolved Solids (mg/l)	944	1,210	1,260
Total Suspended Solids (mg/l)	1,610	5	5
Aluminum (mg/l)	<0.001	<0.001	<0.001
Arsenic (mg/l)	<0.001	<0.001	<0.001
Barium (mg/l)	<0.01	<0.01	0.06
Beryllium (mg/l)	0.0064	<0.001	<0.001
Bismuth (mg/l)	0.004	0.005	0.006
Cadmium (mg/l)	<0.0002	0.0002	0.0005
Chromium (mg/l)	0.007	<0.001	<0.001
Copper (mg/l)	0.010	0.030	0.001
Iron (mg/l)	0.07	0.10	0.05
Lead (mg/l)	0.024	0.001	0.002
Lithium (mg/l)	0.200	0.120	0.098
Manganese (mg/l)	0.048	0.021	0.019
Mercury (mg/l)	<0.00005	<0.00005	<0.00005
Molybdenum (mg/l)	0.020	0.050	0.015
Nickel (mg/l)	<0.002	<0.002	<0.002
Selenium (mg/l)	<0.002	<0.002	0.004
Strontium (mg/l)	4.72	1.04	0.914
Vanadium (mg/l)	<0.001	<0.001	0.006
Zinc (mg/l)	0.232	0.051	0.086
Anions (meq/l)	14.78	17.91	16.85
Cations (meq/l)	13.91	16.60	18.03
Balance (%)	-3.0	-3.79	3.4

Table D-2 Groundwater Quality of the Upper and Lower Aquifers from American Soda's Solution Mining Well (Hole 20-3).

Parameter	Upper Aquifer		Lower Aquifer
	357 feet	811 feet	1,411 feet
Total Alkalinity as $CaCO_3$ (mg/l)	512	11,800	19,500
Phenol Alkalinity as $CaCO_3$ (mg/l)	0	595	940
Bicarbonate (mg/l)	620	12,800	21,300
Carbonate (mg/l)	0	714	1,130
Boron (mg/l)	0.10	0.26	0.50
Bromide (mg/l)	0.15	0.28	0.20
Calcium (mg/l)	39	61	74
Total Organic Carbon (mg/l)	25.0	64.0	59.2
Chloride (mg/l)	11	444	870
Conductivity, 25°C (µmhos/cm)	1,300	18,300	33,300
Fluoride (mg/l)	0.35	24.2	32.0
Hardness as $CaCO_3$ (mg/l)	376	166	193
Hydroxide (mg/l)	0	0	0
Magnesium (mg/l)	63	4	2
Nitrate (mg/l)	0.21	4.13	11.8
Nitrite (mg/l)	0.08	<0.01	<0.01
pH (units)	7.9	8.3	8.3
Phosphate (mg/l)	0.47	0.78	1.35
Total Phosphorous (mg/l)	0.48	1.17	1.65
Potassium (mg/l)	1.1	11.1	21.6
Silica (mg/l)	25.3	9.4	8.4
Sodium (mg/l)	148	5,730	8,620
Sulfate (mg/l)	185	2	28
Sulfide (mg/l)	<0.1	0.1	0.2
Total Dissolved Solids (mg/l)	958	15,900	26,600
Total Suspended Solids (mg/l)	141	17	389
Aluminum (mg/l)	<0.001	<0.001	<0.001
Arsenic (mg/l)	<0.001	0.01	0.077
Barium (mg/l)	0.04	2.24	1.72
Beryllium (mg/l)	<0.001	<0.001	0.003
Bismuth (mg/l)	0.004	0.063	0.097
Cadmium (mg/l)	0.0004	0.0016	0.0017
Chromium (mg/l)	0.003	0.004	0.002
Copper (mg/l)	0.008	0.003	0.401
Iron (mg/l)	<0.01	0.70	1.44
Lead (mg/l)	0.002	0.007	0.306
Lithium (mg/l)	0.085	0.767	1.68
Manganese (mg/l)	0.123	0.007	0.041
Mercury (mg/l)	<0.00005	<0.00005	<0.00005
Molybdenum (mg/l)	<0.001	<0.001	0.070
Nickel (mg/l)	<0.002	<0.002	<0.002
Selenium (mg/l)	<0.002	0.002	0.004
Strontium (mg/l)	1.99	0.393	0.321
Vanadium (mg/l)	0.10	0.47	1.15
Zinc (mg/l)	0.561	0.126	3.58
Anions (meq/l)	14.35	252.9	414.3
Cations (meq/l)	13.59	248.1	379.5
Balance (%)	-2.7	0.96	-4.4

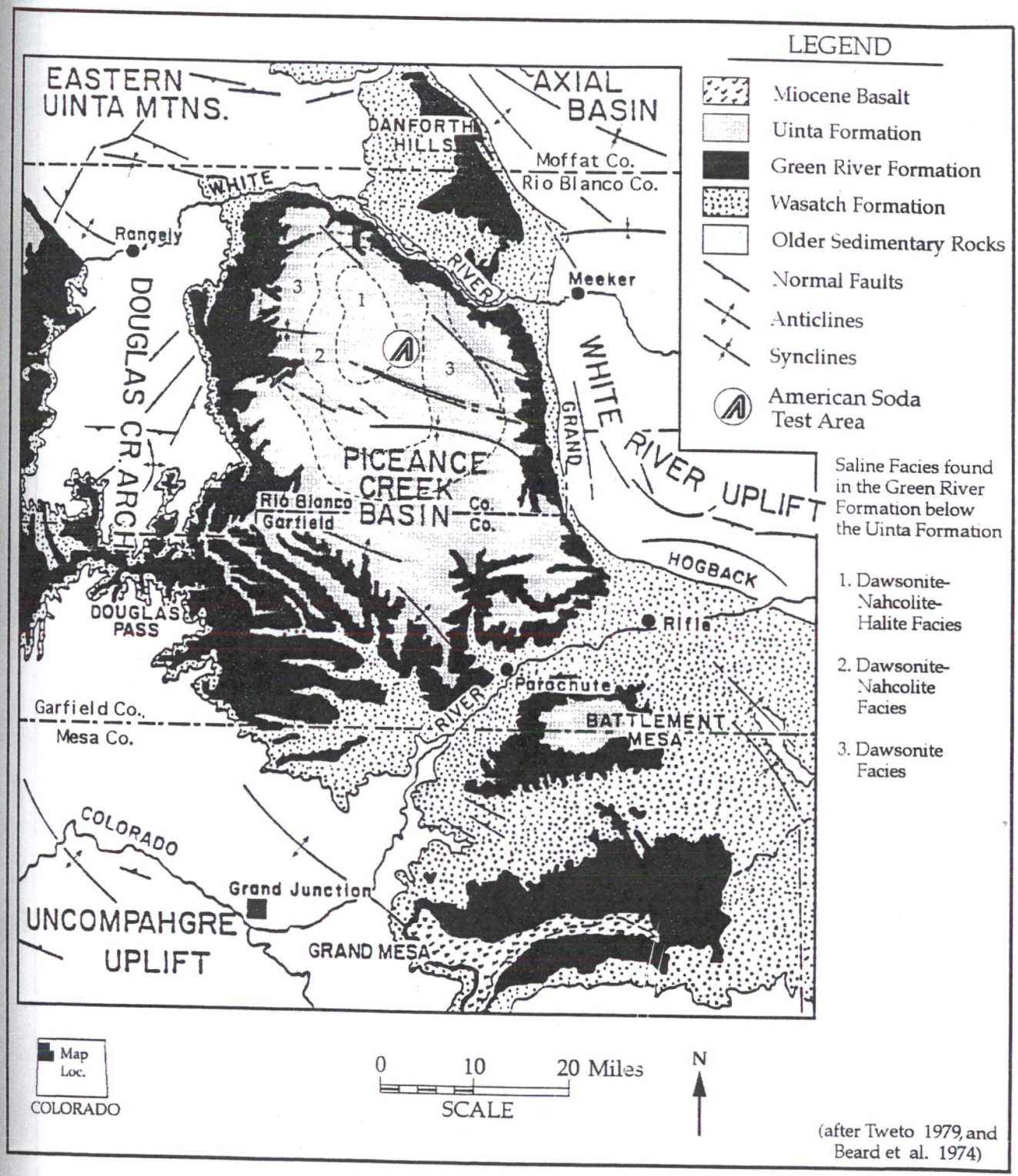


Figure D-1 Geologic and structural map of Piceance Creek Basin, northwestern Colorado.

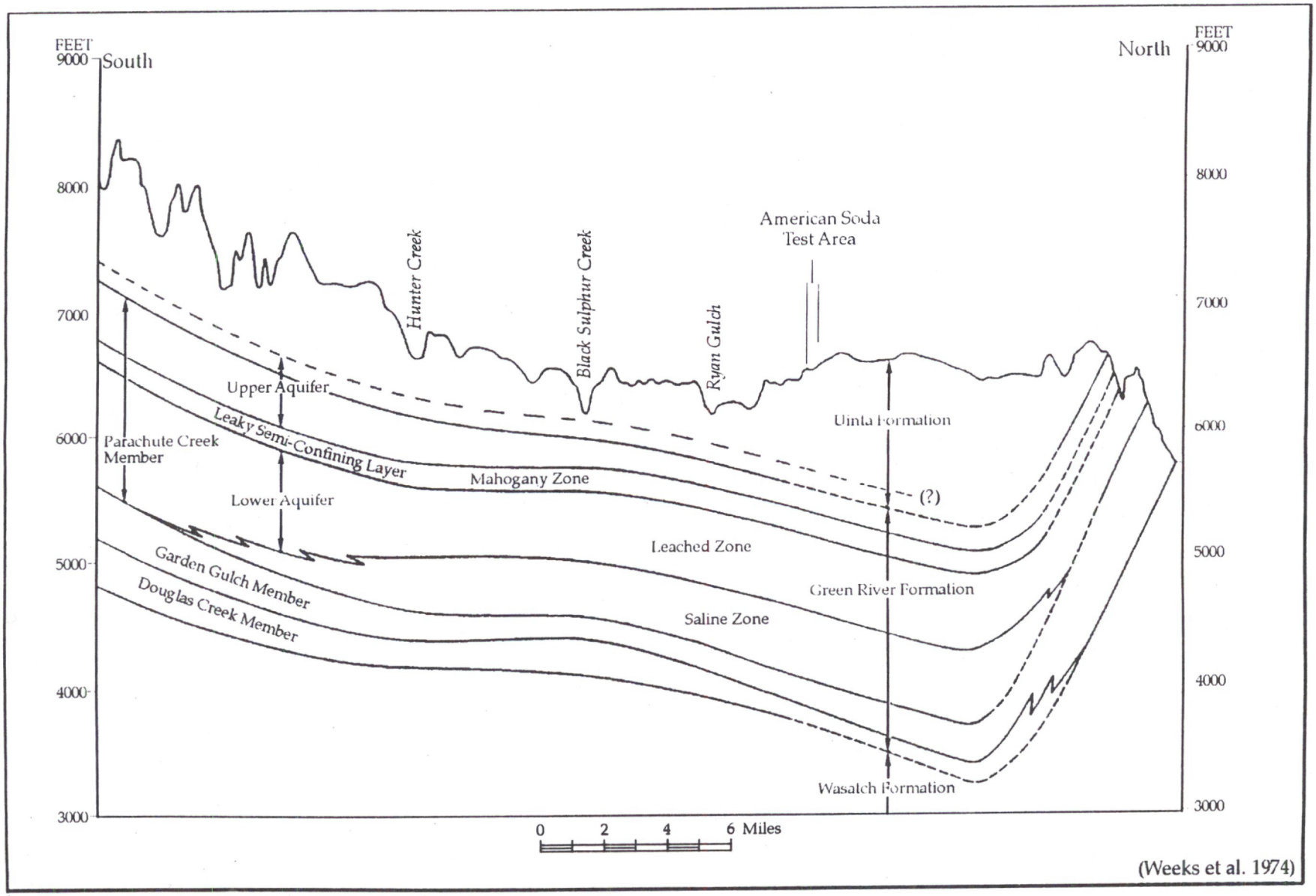


Figure D-2 Regional south-to-north cross section across the Piceance Creek Basin.

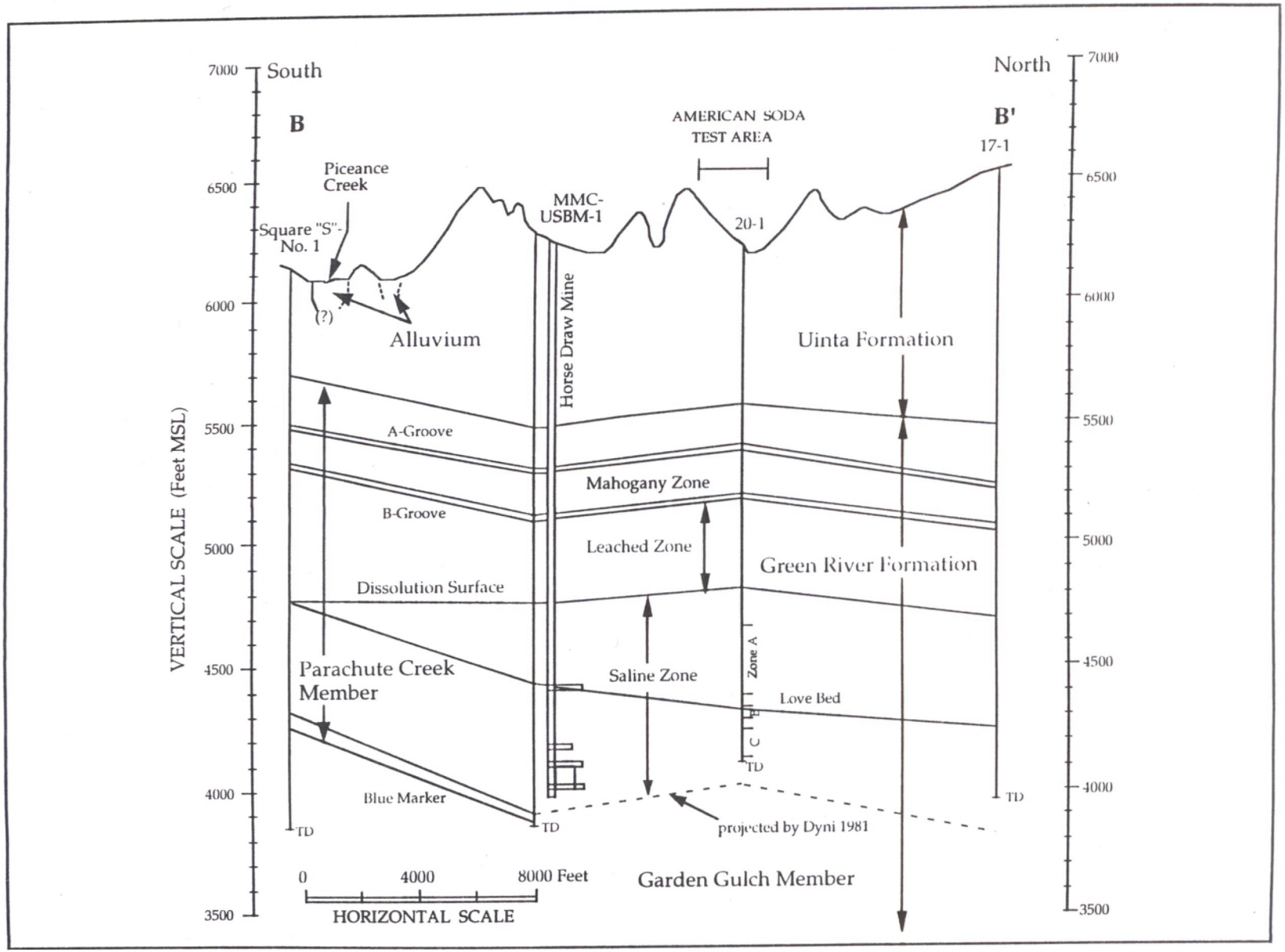


Figure D-3 South-to-north cross section B - B' of American Soda Test Area.